COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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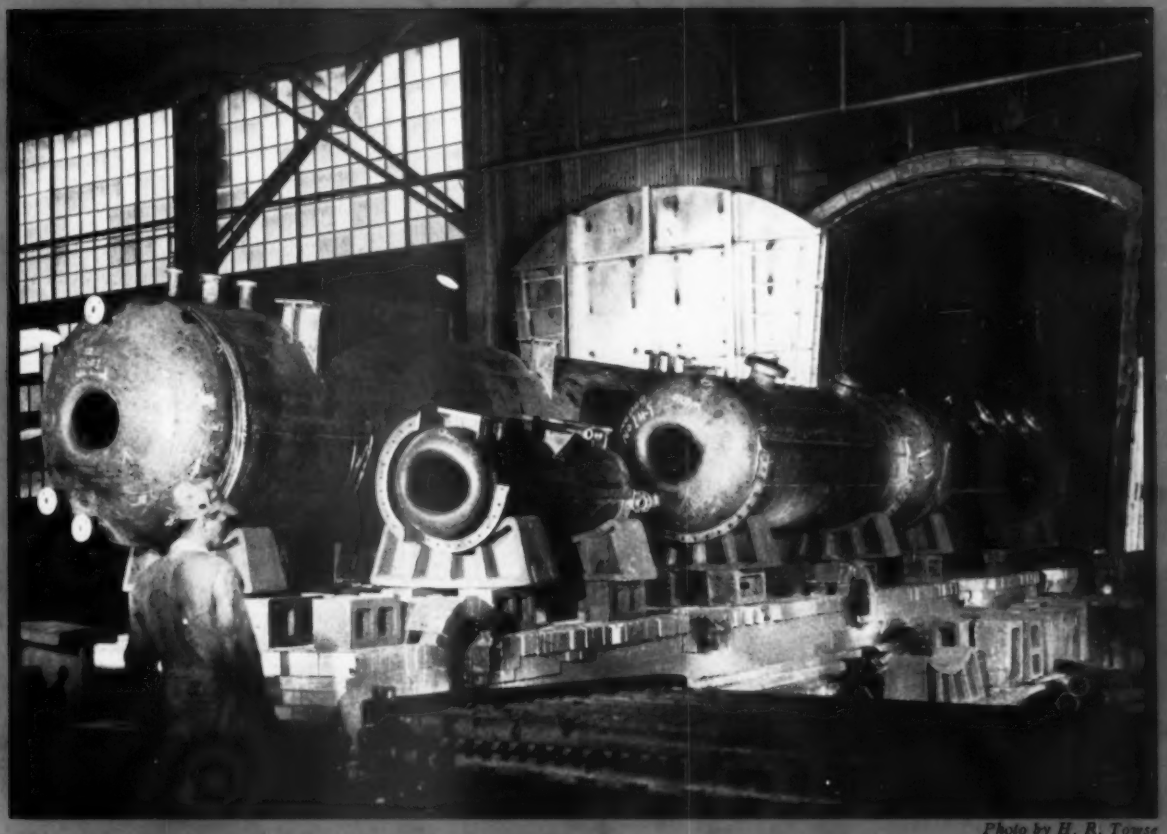


Photo by H. R. Towse

Welded boiler drums entering stress-relieving furnace

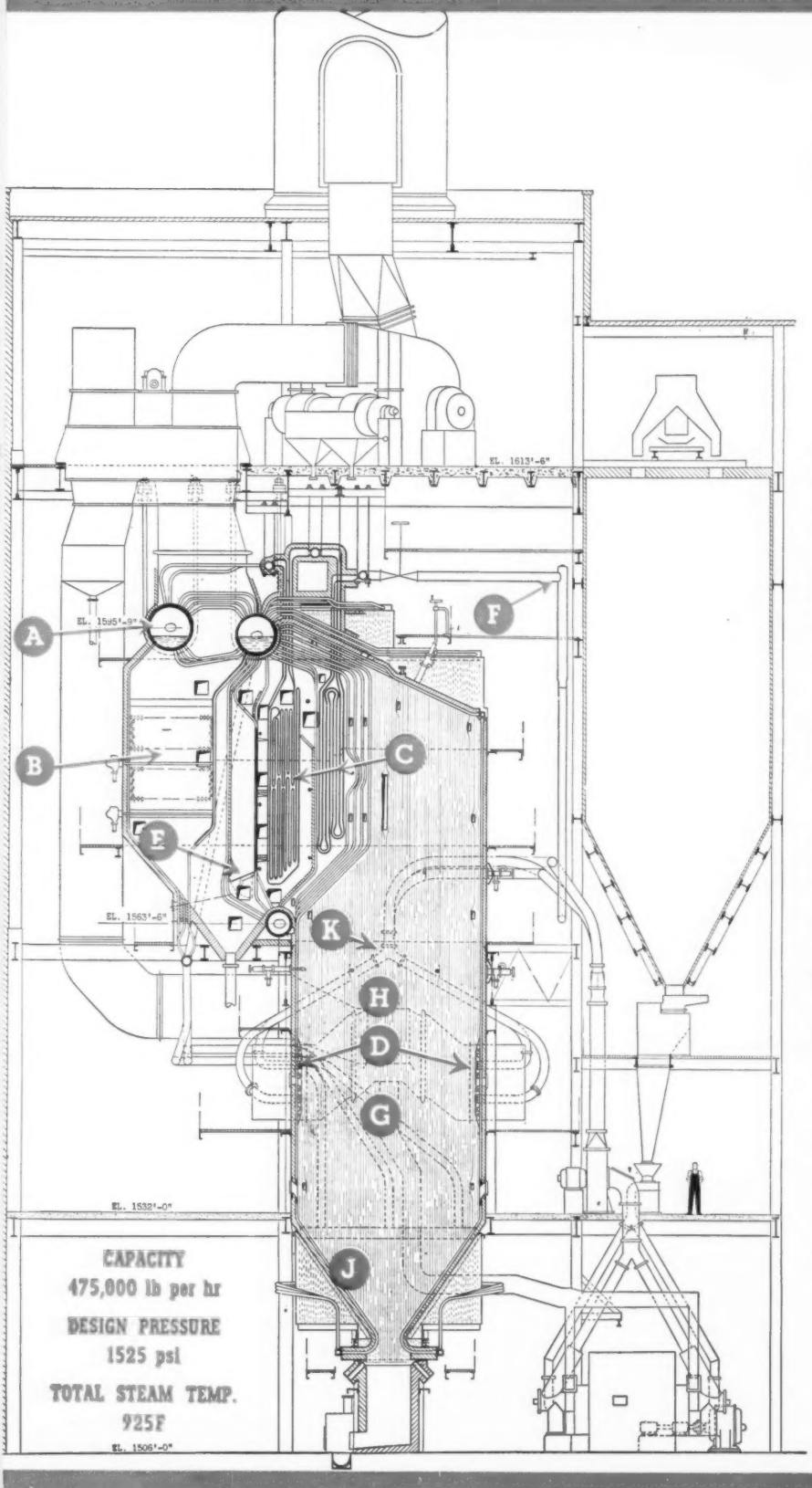
Smoke Density Measurements at Conners Creek Power House

Electric Boilers in the Northwest

Flow of Coal in Chutes at Riverside Station

Present day TRENDS in UTILITY Steam Practice

as reflected in design characteristics of recent C-E Units



One of two units for AMERICAN GAS AND ELECTRIC SERVICE CORP. installed in

GLEN LYN STATION

Appalachian Electric Power Company, Glen Lyn, Va.

Principal Design Characteristics

A 3-drum boiler with large rear top drum providing ideal conditions for final steam cleaning and separation.

B Compact arrangement of economizer in last boiler pass.

C Two-stage superheater with widely spaced tubes in first stage permitting low gas velocities and thus minimizing slag accumulation. Boiler and superheater surfaces in this area completely accessible for cleaning.

D Vertically adjustable burners permitting control of gas temperatures entering boiler and superheater and providing primary control of steam temperature.

E Bypass damper which provides secondary control of steam temperature.

F Spray type desuperheater which assures final close control of steam temperature.

G Tangential firing providing maximum turbulence and rapid completion of combustion.

H Simple, clean-cut furnace of ample volume for low heat release rates and with solid metal surfaces on all sides, top and bottom. All surfaces readily accessible for cleaning.

J Completely water-cooled hopper which, in conjunction with adjustable burners, permits full utilization of lower furnace heating surfaces.

K Arrangement of mill piping which permits each mill to supply fuel to all four corners of furnace.

A-871

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME SIXTEEN NUMBER ELEVEN

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1908

Introduction of thermal expansion type regulator invented by James W. Copes. The first real step toward effective feed water control.

1913

Copes Engineers announce new and revolutionary method of feed water control—"continuous feed varying with load, and level varying inversely with load."

1916

Initial research on flow through control valves, leading to design for individual boiler conditions.
First 6-inch regulator ever made installed at Delray Station, Detroit Edison Company.

1917

Research into the influence of excess pressure variations on feed regulation, resulting in development of first differential pressure devices.

1918

Development of rotary stem control valves to reduce stem friction to low and constant amount, as against high variable friction of sliding stem.

1919

Manufacture of Copes Regulators begun in foreign countries. Within a few years Copes became the accepted standard in Europe, Asia, South Africa.

1920

Copes Regulators installed on 1100 psi. European-built boilers when 450 psi. was highest pressure in the United States.

1921

Originated tight seating valve fittings having equal upper and lower seat areas. Patent granted.

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Copes Regulators designed with expansion tubes in TENSION set new record in simplicity and reliability. Patent granted.

1926

First successful multiple element feed water control—Copes—installed at Ford Motor Company.

1927

Copes installed on first 1400 psi. boilers in the United States—Boston Edison Company.

1928

Basic patents secured on combination of feed water regulator and differential pressure valve.

1930

First 8-inch feed water regulator—a Copes—installed at New York Steam Company.

1932

After careful tests and investigations, all radio controlled ships of U. S. Navy equipped with Copes Regulators.

1934

Six years' research completed with development of first valves really balanced under operating conditions.
Patents granted on 2 types of 3-element regulators.

1937

Patents granted on remote control of feed water regulator and other control valves.

1938

Produced the Copes Flowmatic, a 2-element regulator—recognized as one of the greatest advancements in the art of feed water control for modern boilers.

1941

Introduced a Copes Marine Regulator not influenced by roll or pitch of the vessel. Now installed on hundreds of ships.

1942

Copes Flowmatics installed on largest forced circulation boiler in the world—650,000 lbs. per hour at 1825 psi.—Montaup Electric Company.

194X

Peacetime application of developments and improvements fostered by intensive war production activities.

EDITORIAL

May Eighth

As this is written the official announcement of V-E Day has been made and showers of paper and streamers are enveloping the skyscrapers of New York to mark pent-up feelings on Germany's capitulation. It is a scene that is probably being enacted in varying degree throughout the Nation, as well as in allied countries.

Many factors have entered into the overall effort that has made this possible, each of which has contributed its share and deserves unstinting credit. It is no detraction from the praise due the leaders of the Allied Armies, the valor of the boys on the fighting fronts in Europe, the indomitable spirit of the British and the resurgence of the Russians, to point out that today's celebration would have been impossible had it not been for the productive might of this country in supplying weapons, planes, transportation and supplies to back up the armed forces of all the Allies. This has been a mechanical war to a greater extent than any previous conflicts.

Less glamorous, but none the less important, has been the supply of power that made our productive effort possible. At no time since Pearl Harbor has any war production suffered through lack of power, despite vast increases in load and the heavy burden imposed upon equipment. Many expedients were necessary but neither rationing of power nor curtailment of service had to be adopted. All identified with this phase of the war effort can feel just pride in the accomplishment.

Stopping Fuel Waste

It is generally considered that small power plants, due chiefly to lack of expert supervision, are a more prolific source of fuel waste than large plants. While this is probably true in the aggregate, it is not to be taken for granted that large plants offer little opportunity for effecting substantial savings. Obviously, the optimum efficiencies attainable in most small plants are less than those usually found in large installations which incorporate more refinements in design; but this is not to be confused with preventable waste. Because of the extent and diversity of the services usually supplied by large industrial power plants, the potential opportunities for undetected losses are multiplied and possible savings may be of considerable magnitude.

The current nationwide Fuel Efficiency Program has demonstrated that substantial fuel savings can be made in some of our supposedly best operated plants. By surveying all possible sources of leaks and waste of heat, by guarding against idling motors and unnecessary lighting, and by rescheduling certain process operations, surprisingly large savings have been effected in a number of cases.

According to the Solid Fuels Administration the output of bituminous coal mines from the first of the present year to April 21 was approximately 17 million tons under that for the corresponding period last year and as late as May fifth Secretary Ickes announced that the Government found it necessary to take possession of thirty-three bituminous coal mines whose employees had failed to return to work under the approved contract between mine owners and the miners' union.

Thus it will be seen that, despite cut-backs in war production, the fuel situation is still serious and the need for vigilance in eliminating waste is still very real.

The Seventh War Loan

The good news from Europe must not be permitted to detract from a realization that we still have a tough war to prosecute in the Pacific, which must be adequately financed. Moreover, a fighting force of approximately ten million will have to be fed and paid for many months to come; most of those now in Europe will have to be transported either home or to the Far East; severance pay and educational opportunities and other benefits under the G.I. Bill of Rights are estimated to entail from five to ten billion dollars; hospitalization and pensions for disabled veterans will cost vast sums for many years; lend-lease will be with us for another year at least; and our share of the amount required by U.N.R.R.A. for rehabilitating and feeding devasted countries is large. In addition there is the interest on a mounting national debt which must be met.

This year only two loan campaigns are scheduled, but the Treasury Department expects to raise a total comparable with that raised in the three loans of last year. The Seventh War Loan, which runs from May fourteenth to June thirtieth, has as its goal fourteen billion dollars, divided equally between individuals and corporations. This time special stress is being placed on the sale of bonds to individuals. In some of the previous drives these have lagged behind expectations whereas the corporate purchases exceeded their quotas. However, with war contracts tapering off and reconversion ahead for many firms, purchases by corporations may not exceed their quotas as they did in the past. Therefore, it is important that the individual purchases do not fall down. The value of these bonds as the soundest kind of investment needs no elaboration.

The money must be raised. Should borrowing fail, the alternative is increased taxation.

It is believed that engineers, perhaps more than the average man, fully appreciate the situation and can be counted upon to do their part.

Smoke-Dust Density Measurement at Conners Creek Power House

By H. E. BUMGARDNER

Research Engineer, The Detroit Edison Company

This article describes the development of, and operating experience with, an instrument for indicating and recording smoke-dust density. While in this particular case there are two boilers per stack, the scheme is adaptable to power plants with any number of boilers per stack. The instrument provides both an instantaneous indication of smoke-dust density for the guidance of the boiler operator and a permanent and continuous chart record. The reading obtained is the smoke-dust density in the breeching on a 0-to-100 per cent scale and is equivalent to that at the stack discharge, throughout the entire range of densities, with one or both boilers in operation.

SEVERAL years ago an investigation was started to find a satisfactory smoke recorder. A number of instruments representative of all the better types available on the market were investigated. Actual installations of certain of the more promising of these were made and the instruments subjected to test either at Delray Power House or at Conners Creek Power House.

The type of instrument sought was one that would:

(*a*) give smoke-dust density readings equivalent to those at the stack discharge when either one or both of the two boilers per stack were in operation;

(*b*) have a light-sensitive cell that aged very slowly, if at all;

(*c*) have a light source that was unaffected by voltage fluctuations in the instrument circuit;

(*d*) provide means for insuring that the lenses remain clean with a minimum of attention;

(*e*) provide means for insuring that the light-sensitive cell would not fail as a result of the temperatures encountered when mounted alongside of breechings;

(*f*) include a means of calibration and of checking the zero point, while the boilers were in operation;

(*g*) provide means for determining how much each boiler alone was smoking when both boilers were in operation; and

(*h*) give an alarm when a predetermined smoke-dust density was reached and exceeded.

None of the instruments tested were found to be satisfactory for the purpose. The main objection was that the readings obtained from the instruments bore no relation to the readings that were obtained by smoke chart methods at the stack discharge. It was not possible to

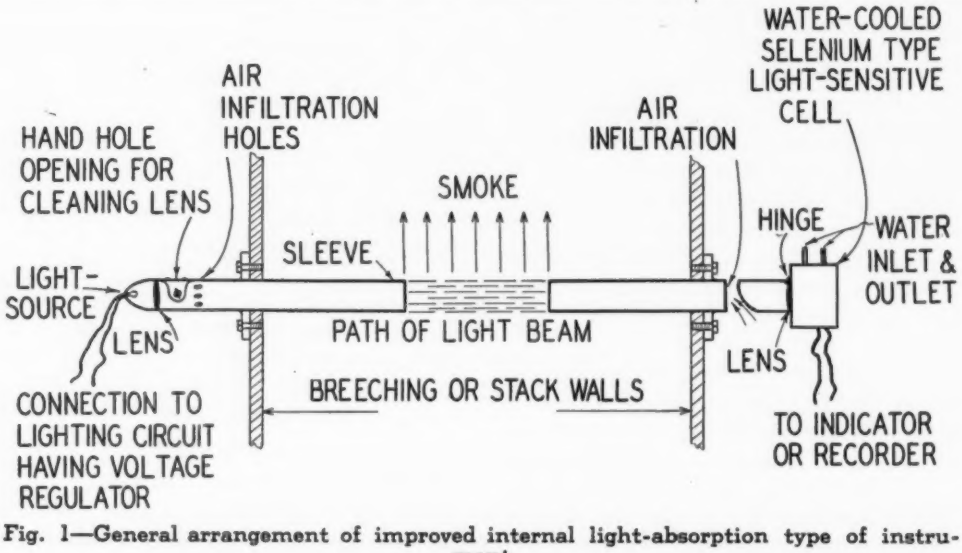

Fig. 1—General arrangement of improved internal light-absorption type of instrument

adjust the instrument to give comparable readings, except in the lowest range of densities.

In order to obtain an instrument combining all of the desired features it was necessary to develop the instrument described herein.

Having a given light source, sensitivity of photoelectric cell, and type of recorder, the length of column through which measurements are taken is chosen to give a scale of readings comparable with those obtained at the stack discharge.

The smallest breeching width available for installation of the light source and light-sensitive cell is always too great to permit readings that are equivalent to those at the stack discharge. In order to obtain the necessary small thickness of flue gas through which measurements may be made, sleeves[1] must be used. With a flue gas column thickness greater than about 15 to 25 in., varying according to the stack diameter, readings are obtained that increase very rapidly with increase in density and much more rapidly than the readings of the stack discharge.

Visual observations of density at the stack discharge by smoke chart methods are subject to many extraneous influences. The visual observations used in determining the proper sleeve spacing (see Fig. 1), however, were taken only when conditions were favorable for such measurements. Thus, the errors in this case were practically eliminated.

When two or more photoelectric cells, such as those employed in the indicator-recorder described herein, are

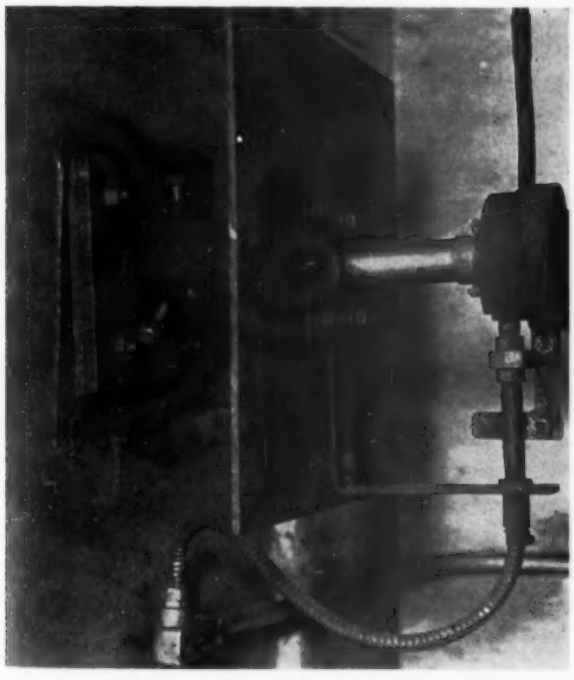

Fig. 2—View of selenium-type, water-cooled, light-sensitive cell as installed on one of the boilers

connected *in parallel*, the smoke-dust density readings obtained on the indicator-recorder are equal to the sum of the density readings for the individual cells. The total reading given by the indicator-recorder is slightly greater than the apparent density of the gases at the stack discharge. Thus, for example, if the density reading from one boiler is 20 per cent and from the other boiler 20 per cent, then the recorder reading is 20 + 20 = 40 per cent. The apparent density at the stack discharge, however, equals 20 + 16 or 36 per cent.[2]

An adjustment to the power unit or to the indicator-recorder will bring the instrument and stack discharge readings into agreement at any particular density reading and very nearly equivalent throughout the remainder of the 0-to-100 instrument scale.

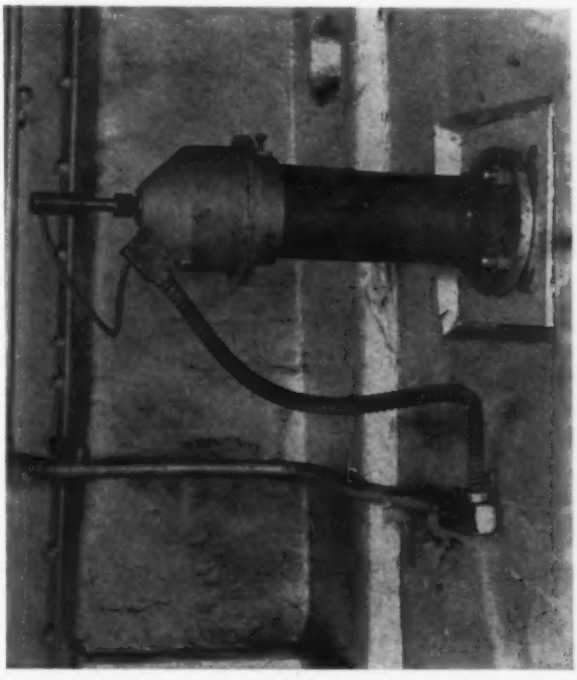

Fig. 3—Filament lamp and reflector forming part of smoke recorder on one boiler

Description of Equipment

The breeching installation is shown schematically in Fig. 1 and the complete instrument comprises:

(1) Two selenium-type, water-cooled light-sensitive cells, Fig. 2, and two filament lamp and reflector light source units, Fig. 3 (one set for each boiler), installed across the breeching where the pressure is always below atmospheric. The sleeves shown in Fig. 1 provide the means for obtaining the proper thickness of smoke-dust stream to give indicator-recorder readings that are closely equivalent to the density readings observed at the stack discharge.

(2) A power unit which includes a voltage regulator and a step-down potential transformer with variable voltage taps, shown in Fig. 4. The voltage regulator assures the necessary constant light source required for this type of instrument. The step-down transformer provides means for adjusting or changing the intensity of the light source.

[1] See U. S. Patent No. 1,785,392 issued to Frank Sawford et al., December 16, 1930.

[2] For explanation of the latter, see *A.S.M.E. Instruments and Apparatus*, Part 20—Smoke Density Determinations, *Pub. PTC 19.20.*

(3) A round-chart, current-measuring potentiometer-type, single-point, combination indicator-recorder, Fig. 5, with an adjustable alarm contact for measuring the smoke-dust density from the two boilers combined or either one separately, as desired.

(4) A three-position, pistol-grip selector switch, also shown in Fig. 5, for connecting the light-sensitive cells into the indicator-recorder circuit, either boiler singly or both in parallel. In place of this type of selector switch, a push-button type switch might be used.

(5) Two light signals placed on the boiler gage boards which flash on when a predetermined smoke-dust density setting is reached. The lights remain on until the density is reduced below the cut-in point.

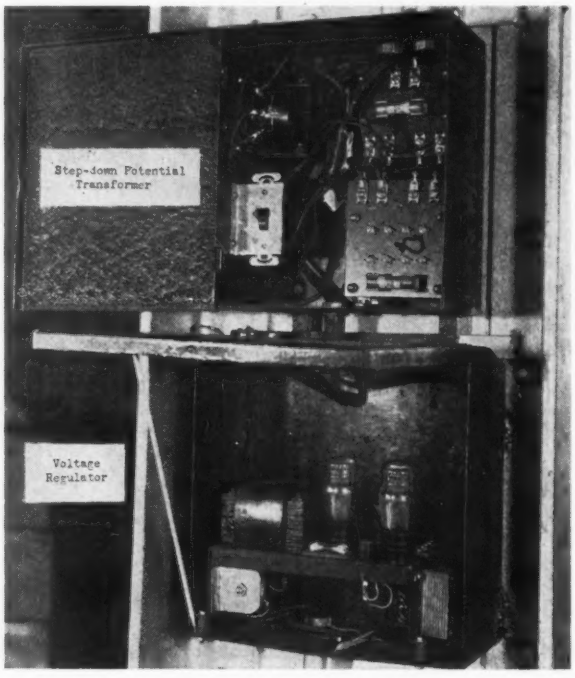

Fig. 4—Power unit, including voltage regulator and step-down potential transformer

Individual Setup Employed for Each Boiler

A separate breeching installation of light-sensitive cells and light sources for each boiler was selected in preference to a single outdoor stack installation because, with the former, (*a*) it is possible for the boiler operator to determine how much each individual boiler is smoking, and (*b*) the fan room provides a much more convenient location for keeping the lenses clean and calibrating the instrument.

As mentioned previously, the instrument gives smoke-dust density readings which, although not exactly equivalent to those at the stack discharge, are very nearly the same. They agree closely throughout the entire range of densities regardless of whether either one alone or both boilers are in operation.

Precautions

An internal light-absorption type instrument such as the one described, which requires a constant light source, should be provided with a voltage regulator to eliminate the smallest fluctuation of voltage in the instrument circuit. A change in line voltage of even as little as one volt will produce an appreciable change in the density reading.

The light-sensitive cell employed is of the type that will not withstand the higher temperatures sometimes encountered adjacent to the breeching. In order to prevent deterioration due to temperature, the cell is encased on all surfaces except its face so that it may be water cooled. A piece of transite (Fig. 2) also is employed to shield the cell from direct radiation of heat from the breeching.

The light source and light-sensitive cell, each of which is protected from dust deposits by a lens, are as mentioned before installed where the pressure within the breeching is slightly below atmospheric. Air infiltration through openings in one of the sleeves and into the open end of the other sleeve, as shown in Fig. 1, keeps the lenses clean for several days. However, as a precautionary measure the breeching sides of the lenses are cleaned once every eight hours. The light source is taken apart and thoroughly cleaned once each month in order to eliminate any fan-room dust that may have entered around the gaskets and deposited either on the reflector or on the inner face of the lens.

The particular design of lamp used as a light source is important. One that will not be affected by vibration or wear of the contacts should be used. Either a prong-type lamp or an ordinary automobile headlight lamp, used in an extension holder to prevent a shifting of the position of the light source, is satisfactory for the purpose.

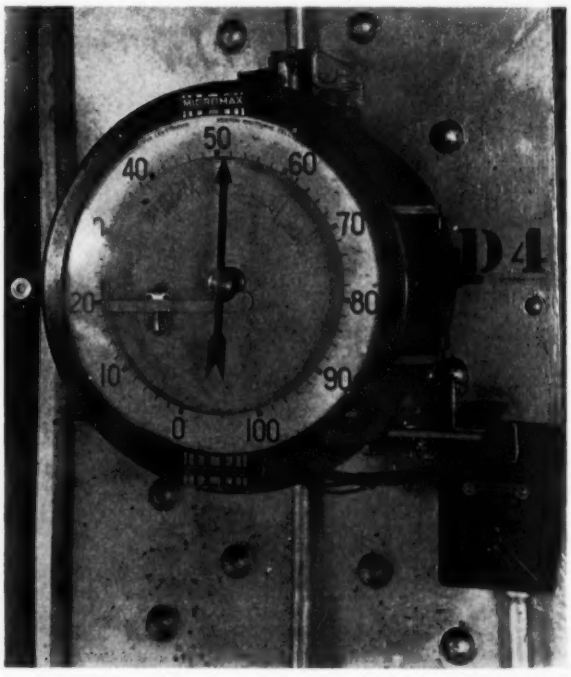

Fig. 5—Combination smoke indicator and recorder with selector switch

Calibration

With the sleeves, it is an easy matter to eliminate the smoke-dust in the light path and thus be able to calibrate the instrument while the boiler is in operation. This is accomplished by disconnecting the light-source unit and inserting a slightly smaller pipe inside the sleeves and across the opening between the sleeves. With the light-source unit reinstalled and all smoke-dust in the light path eliminated, the instrument is calibrated or checked by means of the calibrated blackened wire screens shown in Fig. 6. These are inserted one at a time in front of the light-sensitive cell, and the readings of the instrument noted. If the instrument is out of adjustment, the intensity of the light source is varied by means provided for this purpose. The four screens shown give four points on a 0-to-100 per cent scale.

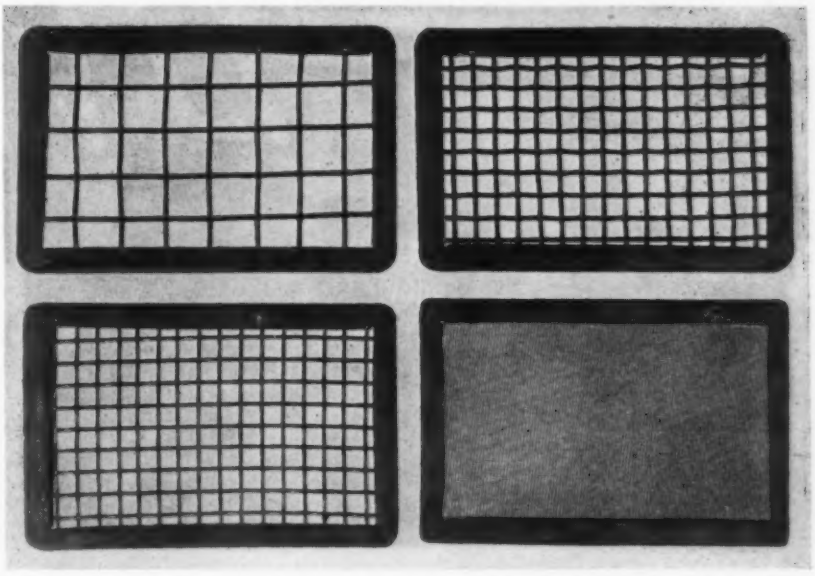

Fig. 6—Calibration screens

In arriving at the proper spacing of the sleeves, smoke density observations of the stack discharge, under ideal weather and wind conditions, were made when only one boiler was in operation. One of the improved smoke charts,[3] based on a 0-to-100 per cent density scale, was used. Such a chart also is employed whenever the instrument readings are checked against the density readings at the stack discharge.

[3] See *ASME Instruments and Apparatus*, Part 20—Smoke Density Determinations, *Pub. PTC 19.20.*

Results

A complete indicator-recorder assembly, such as that described, has been in operation at Conners Creek Power House for about six years. Inasmuch as noncomplicated standard equipment is employed, maintenance is reduced to the occasional replacement of parts that age, such as the filament lamp.

The water-cooled photoelectric cells maintain their calibration and show little or no signs of aging.

Figs. 7 and 8 show two representative charts obtained from the indicator-recorder instrument. It will be noted that the instrument is responsive to even slight changes in density or in boiler operation.

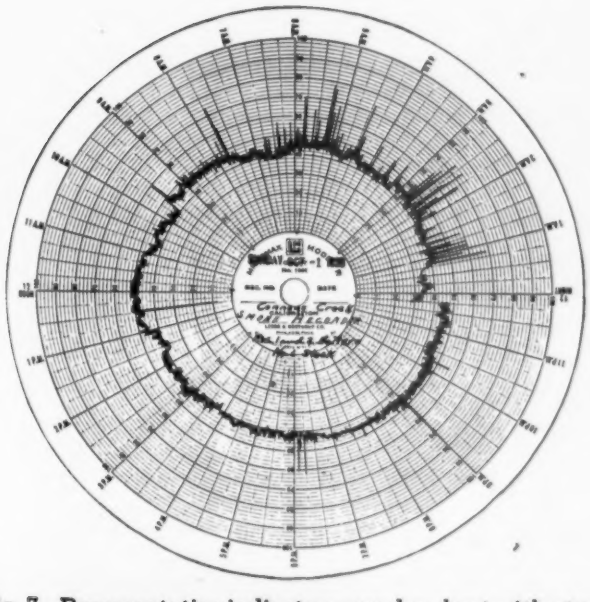

Fig. 7—Representative indicator-recorder chart with steady boiler output

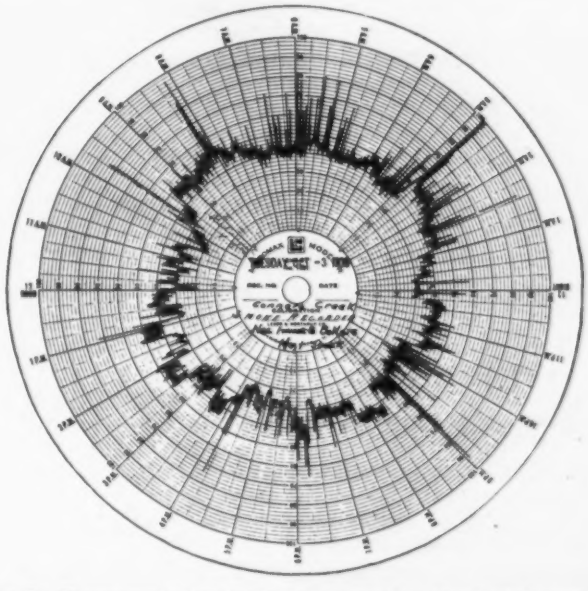

Fig. 8—Representative indicator-recorder chart with varying boiler output

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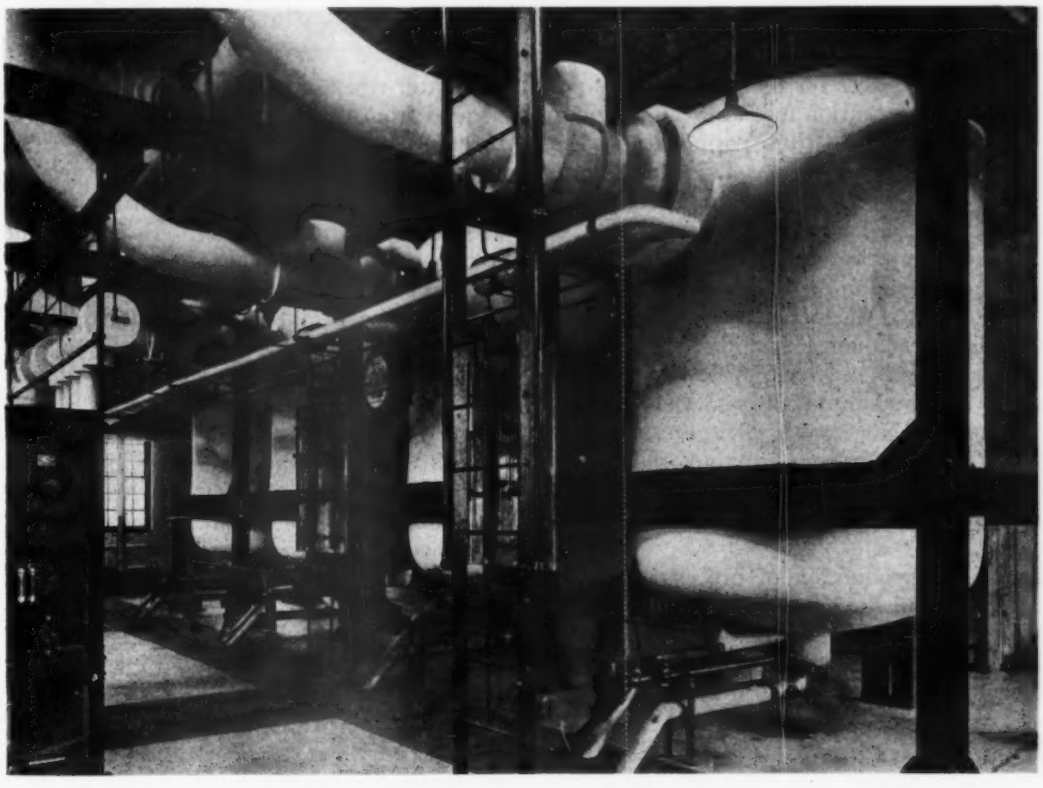
ELECTRIC BOILERS IN THE NORTHWEST

While much of the vast amount of hydro power installed in the Pacific Northwest by the Federal Government is now being utilized in war production, large blocks will be released in the post-war period and the Bonneville Power Administration, in a survey of potential markets for this electricity, sees one opportunity in its wider use for the generation of steam, particularly for the process industries. Low secondary power rates for such applications are under consideration. Information on electric boilers, as generally used in this country and Canada, are included in the following notes.

THE Federal Government thus far has invested over 300 million dollars in hydroelectric projects in the Pacific Northwest. This includes both straight power developments and multi-purpose projects covering irrigation and navigation as well as power. Outstanding among these are the Bonneville and the Grand Coulee developments on the Columbia River. The former, situated about 35 miles east of Portland, Ore., and constructed by the U. S. Corps of Engineers, has an installed capacity of over half a million kilowatts; whereas the latter on the upper Columbia in Washington is operated by the U. S. Bureau of Reclamation and has installed approximately 600,000 kw or about one-third of the estimated ultimate capacity. A series of other federally planned dams and power projects on this river, in addition to the existing Rock Island development of the Puget Sound Power & Light Company, will comprise the ultimate development of the Columbia River basin.

Capacity Speeded by War

Although this was conceived and planned in the early thirties with a view to providing irrigation and widespread power facilities for speeding the industrial and agricultural growth of the Northwest, the war hastened the installation of more capacity than otherwise would have been made by this time. The availability of this power led to the location of a number of war production plants in this region, particularly those requiring large blocks of electric energy.



Typical electric-boiler installation

As a post-war problem the Government is naturally looking forward to markets for this power that will be released when war production ceases. It hopes, by means of exceptionally low rates, to attract certain peacetime manufacture that will serve the needs of that region and at the same time be an important factor in employment. This is one of the tasks of the Bonneville Power Administration which some months ago completed a comprehensive survey of the situation.

At present the principal industries of the Northwest include aluminum reduction and rolling, lumber, canning, shipbuilding, airplane production, beet sugar, a few small steel plants and some pulp and paper mills. It is aimed to widen this range to include chemical, food and other process industries, as well as agriculture.

Available Fuels

This region has some local coal of sub-bituminous rank and some is brought in from nearby states. Having no oil, this has to be imported from California, Wyoming and Montana. The hogged fuel which was once so plentiful in this region has become relatively less available in recent years.

The drain upon our petroleum resources by the war and the declining rate in discovery of new wells is certain to be reflected in future prices for fuel oil, and it is possible that post-war conservation measures may tend to restrict the use of fuel oil to those applications that cannot well be served by other fuels. This would result in a shift to wider use of wood, coal or electricity for the production of steam in the Pacific Northwest.

The generation of steam by electricity has been practiced for many years abroad in Switzerland and the Scandinavian countries and in the paper and pulp industry of Eastern Canada where over $1^1/_2$ million kilowatts of electric boiler capacity is in service. A few installations have been made in the United States, including ten electric boilers in the Northwest with an aggregate capacity of 250,000 lb of steam per hour, and others which will more than double this figure are now under construction. They include two separate 150,000-lb per hr units of 50,000 kw each.

For the economical production of process steam by electricity, the first requisite is cheap power. Ordinarily, firm power is too costly; hence, many of the existing installations of electric boilers operate on dump or secondary power which may be subject to discontinuance at certain periods. However, where there is a surplus of firm power, extremely low rates may be available.

In making comparison with fuel-generated steam, the cost of fuel and electricity are not the only considerations, as the investment cost with an electric boiler is very much less—from one-quarter to one-fifth. The only auxiliary is the feed pump. No stack, ducts, firing equipment, fuel storage or fuel and ash-handling system are required; the electric boiler can be centrally located in the plant with a consequent reduction in piping; the space required is small and the operating labor a minimum; and maintenance is almost negligible with proper operation. Moreover, steam can generally be raised in about 20 minutes. These are factors that must be weighed in any economic study of the subject.

The efficiency of electric boilers is high, generally from 92 to 95 per cent, or even higher, as the only losses are blowdown and radiation. The latter can be rendered small by proper insulation. Power factor is also high—about 95 per cent. An evaporation of about $3^1/_4$ lb, from and at 212 F, or around 3 lb actual per kilowatt-hour is generally attainable. Pressures are limited to about 250 psi because of the temperature limitations of the insulators employed. However, this pressure is higher than that usually required for process steam. In fact, 150 to 175 psi is more common for such installations.

The two principal types of electric boilers are the resistor design in which the resistance elements are inserted within tubes with the water on the outside, and the water-resistance design in which electrodes are suspended from the top of the tank and the current passes through the water to a neutral plate. The latter type, as exemplified by the Kaelin boiler, was introduced in Canada nearly 25 years ago and is the one most widely used in the United States. It is less bulky than the resistor type and employs alternating current, inasmuch as direct current would set up electrolysis and liberate both hydrogen and oxygen. Except for very small capacities three-phase current is used.

ESTIMATED COST OF STEAM GENERATION WITH THE ELECTRIC BOILER, AND WITH THE FUEL-FIRED BOILER USING NORTHWEST FUEL

Items	Electric Boiler, per Kwh	Hogged Fuel, per Unit—$0.50 cost of delivery	Hogged Fuel, per Unit—$1.25 cost of delivery	Fuel Oil, per Bbl—Portland area	Fuel Oil, per Bbl—Salem area	Fuel Oil, per Bbl—Puget Sound	Coos Bay Coal at Salem, per Ton	Lewis County Coal, per Ton At Salem	Lewis County Coal, per Ton At Portland	King County Coal, per Ton At Portland	King County Coal, per Ton On Puget Sound	Roslyn Coal, per Ton On Puget Sound	Roslyn Coal, per Ton On Spokane area	Fernie Coal, Spokane area, per Ton
Fuel cost	$0.002	$1.25	$2.00	$1.37	$1.56	$1.475	$6.00	$6.00	$5.50	$7.00	$5.50	$6.00	$6.50	$7.00
Cost of steam per 1000 lb:														
Fuel	0.608	0.118	0.188	0.288	0.328	0.310	0.528	0.528	0.485	0.400	0.314	0.342	0.370	0.370
Labor and maintenance	0.016	0.058	0.058	0.047	0.047	0.047	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
Fixed charges	0.009	0.030	0.030	0.041	0.041	0.041	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
Total cost	$0.633	$0.206	$0.276	$0.376	$0.416	$0.398	$0.632	$0.632	$0.589	$0.504	$0.418	$0.446	$0.474	$0.474

Features of Water-Resistance Type

This water-resistance boiler is built either with three separate vertical tanks, one for each phase, or a single tank in which are suspended three electrodes surrounded by a neutral plate in the form of a clover leaf. A dry drum is provided at the top of the water drum for the collection of steam.

The three-tank design is adapted to high voltages, up to 13,200, whereas the single-tank design has been employed in both small and large sizes for voltages as high as 6900 although installations for 2300 volts and lower are more common. Capacities up to 135,000 lb of steam per hour corresponding to 42,000 kw in units of the three-tank design are in service and single-tank units are

under construction for outputs of 150,000 lb of steam per hour, equivalent to 50,000 kw.

The quantity of steam generated is governed by the current passing through the water and this depends on both the resistance of the water and the area of the path through which the current passes. The electrodes are usually tapered and the area is determined by the depth of immersion. Since the purer the water the greater the resistance to the passage of electric current, concentration of solids tends to reduce the resistance which is also reduced with rise in temperature. By means of blowoff and the introduction of the relatively pure feedwater at the bottom of the tank it is possible to maintain the concentration of the boiler water within narrow limits and the quantity of steam generated can then be controlled closely by varying the water level. Usually a 5 to 1 range in load is possible. Automatic control has been applied in some cases, although manual control is more general.

Bonneville Comparisons

The accompanying table, condensed from the report of the Bonneville Power Administration, shows an estimated comparison between the costs per thousand pounds of steam generated by electricity and by fuels available to the Northwest. A unit of 120,000 lb per hr capacity and 150 psi pressure is assumed and the existing rate of 2 mills per kilowatt-hour is used in the calculations. At this rate the cost per thousand pounds of steam with electricity is comparable to that when burning $6 coal of 9000 Btu heating value but it is higher than that with hogged fuel or fuel oil at the prices prevailing last year. However, as previously mentioned, neither the hogged fuel nor the fuel oil situation is assured and the Bonneville Power Administration has under consideration a rate of 1 mill or less for secondary power when employed for steam generation. This would make the cost per thousand pounds of steam comparable with that produced at present by oil.

Summing up its report on this phase of its survey, the Bonneville Administration says:

"To the extent that the available blocks of surplus, secondary or dump power will permit, electric boilers are expected to find a permanent place in the industrial steam plants of the Northwest. Already large electric boilers are in operation in some of the large paper mills and utilities, and others may follow when the power is available at a satisfactory rate. Many small units could be installed in the smaller processing establishments to operate on firm power. Pulp and paper mills tributary to the Bonneville-Grand Coulee system require large amounts of process steam for pulp cooking, evaporation, and drying, and are good prospects for electric boiler installations due to impending shortages of hogged fuel and fuel oil. Roughly, 500,000 kw of low-grade power might find a market in this field. Other prospective fields for electrically generated steam include certain lumber mills, cheese plants and condenseries, and central heating plants, a part of which could be firm power." From this it would appear that the electric boiler is likely to play an important role in steam generation in the Northwest in the post-war period, even though the aggregate capacity of such installations may not be great.

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Flow of Coal in Chutes at Riverside Station

Use of coal from lot storage, with consequent moisture absorption, has caused considerable rat-holing and arching in the bunkers and frequent stoppages in the chutes at the Riverside Station of the Consolidated Gas, Electric Light & Power Company of Baltimore. An experimental investigation involved a study of the flow and stoppage of coal in a transparent scale model of one of the chutes; measurements of physical properties of lot coal with relation to factors causing stoppage; and development of a new design of coal chute. The following are excerpts from a paper reporting this investigation, contributed by the Fuels and Power Divisions of the A.S.M.E. and presented before the Metropolitan Section, New York, May 7, 1945.

By E. F. WOLF and
H. L. von HOHENLEITEN

Consolidated Gas Electric Light
and Power Co. of Baltimore

DURING the winter and early spring of 1943–1944, government regulations of fuel made it necessary to use large amounts of fuel reserves. This led to extensive use of coal from lot storage, which by reason of exposure to weather had absorbed large percentages of moisture. With this wet coal a great amount of rat-holing and arching took place in the bunkers and frequent stoppages occurred in the chutes from the bunker to the pulverizing mills especially at the Riverside generating station. It was decided that a thorough study of this problem would be warranted and an experimental program was mapped out and carried through in the following steps:

1. Study of the flow and stoppage of coal in a transparent plastic scale model of one of the present chutes.
2. Measurements of physical properties of lot coal to study the cause and factors affecting stoppage.
3. The development in successive steps of a new design of coal chute in scale-model form.

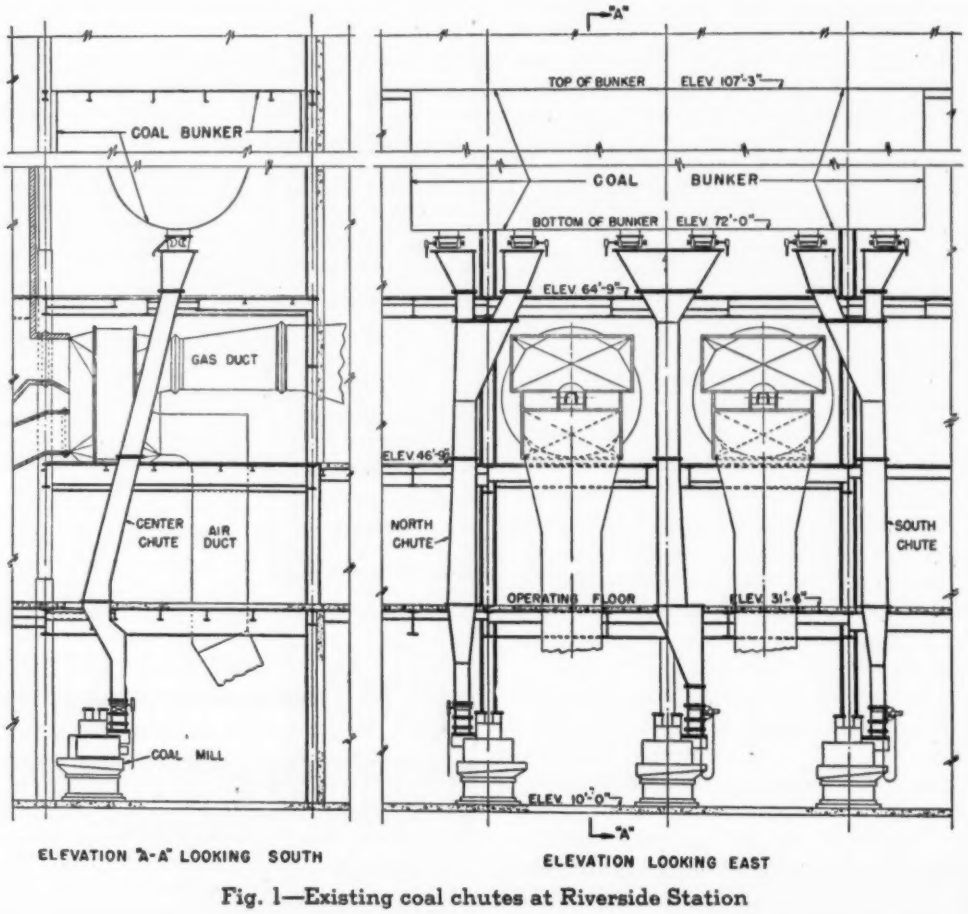

Fig. 1—Existing coal chutes at Riverside Station

It has been observed over a number of years that coal will stick in bunkers and chutes whenever the moisture content exceeds a certain limit for given types of equipment and coal. Stoppages, when using lot-storage coal, have been more frequent at our Riverside than at our other plants, principally on account of the method of storing coal at the former location. The stocking-out and reclaiming of coal by means of a bulldozer and "carry-all," and the greater degree of compacting that the coal undergoes when stored by this means, is apparently responsible for a higher percentage of fines and, consequently, a greater ability of the coal to retain moisture.

Each of the two turbine-generators at Riverside station is served by one 550,000-lb-per-hr boiler which takes its coal supply from a 990-ton-capacity catenary bunker. The bottom of this bunker is located at elevation 72 and is equipped with six clamshell gates. Three chutes, each fed by two gates, carry the coal to the three pulverizing mills located in the boilerhouse basement at elevation 10, Fig. 1. The center chute, which had proved to be the most troublesome in operation, was selected as the subject for this investigation.

Since it was impossible to determine either the exact location or the nature of each stoppage in the coal chutes at the plant, it was decided to make an exact transparent

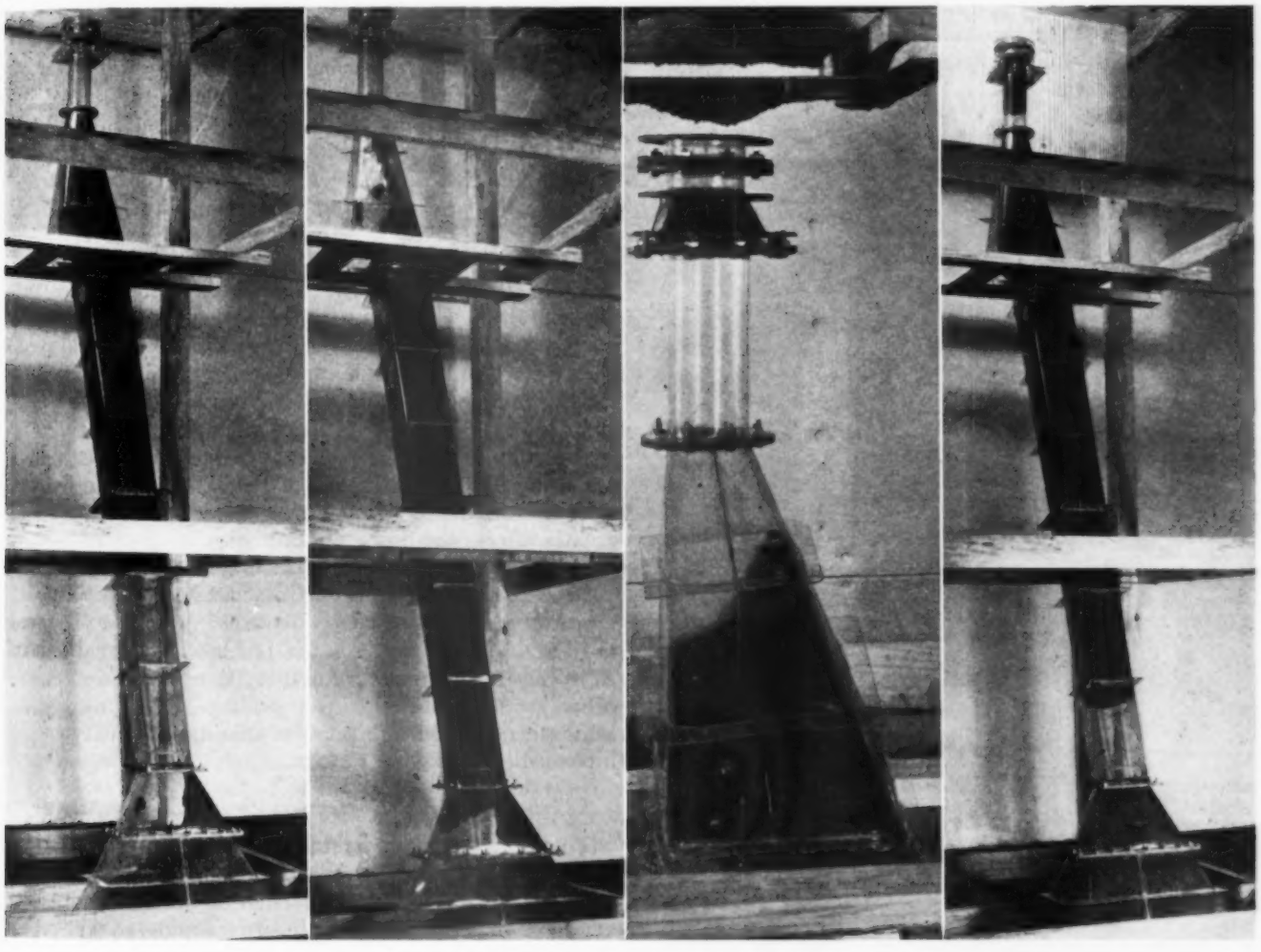

Fig. 2—Views showing sticking and arching of coal in model of existing chute

The fuel used at these stations is semibituminous coal produced in District No. 1 from the central Pennsylvania and northern West Virginia regions.

Practical operating experience had indicated that the coal delivered to our plants by barges normally could be relied upon to flow through the chute system with little difficulty in contrast to troubles experienced with lot-stored coal of similar moisture content. It was believed that the explanation for this was to be found in the physical make-up of the coal. Typical sieve analyses indicate that the consistency of lot coal is such that approximately 30 per cent by weight is finer than number 20 mesh, and that it contains approximately one-third more material of this fineness than scow coal.

scale model of one of the existing chutes. This and most of the later models were fabricated from 30-mil sheet pyralin by molding it under boiling water over polished wood templates which conformed to exact inside dimensions. This material is satisfactory for this purpose since it has a coefficient of friction not greatly different from smooth steel plate. The lineal scale selected was one-tenth full size, which is equivalent to a volume reduction of 1000 to 1. Experiments were conducted with this model using specially prepared coal samples having particle sizes reduced approximately to the lineal-scale reduction of the model. Most of the experiments were carried out, however, with coal samples taken directly from lot storage and slightly modified by

removal of lumps larger than ½ in. size. A revolving-table feeder was installed at the outlet of the model to simulate the action of the table feeder at the Riverside plant. Phenomena observed in the actual chutes have been reproduced to a surprising degree in the model with either gradation of coal. Sticking and "hanging up" have occurred in the model at the same location and in the same manner at which sticking could be observed in the prototype.

In the operation of the model of the existing chute, the flow of dry coal was found to be smooth and uniform. At about 2.5 per cent moisture, the flow became very sluggish along the corner of least slope in the hopper below the operating level (elevation 31 ft 6 in., Fig. 1). Most of the flow occurred in a spiral motion along the opposite vertical corner. The movement of coal from the chute above occurred almost entirely on the side where the hopper below was offset. With further increase in moisture the coal began to rat-hole intermittently by draining entirely from the vertical corner and leaving the remainder of the hopper packed with coal. The observation of these phenomena which have been noted frequently in the field, was aided in the model by the use of thin horizontal layers of inert white powder placed at intervals in the coal stream. Two other early points of trouble were the bottom of this hopper and the hopper-like shape simulating the coal gate.

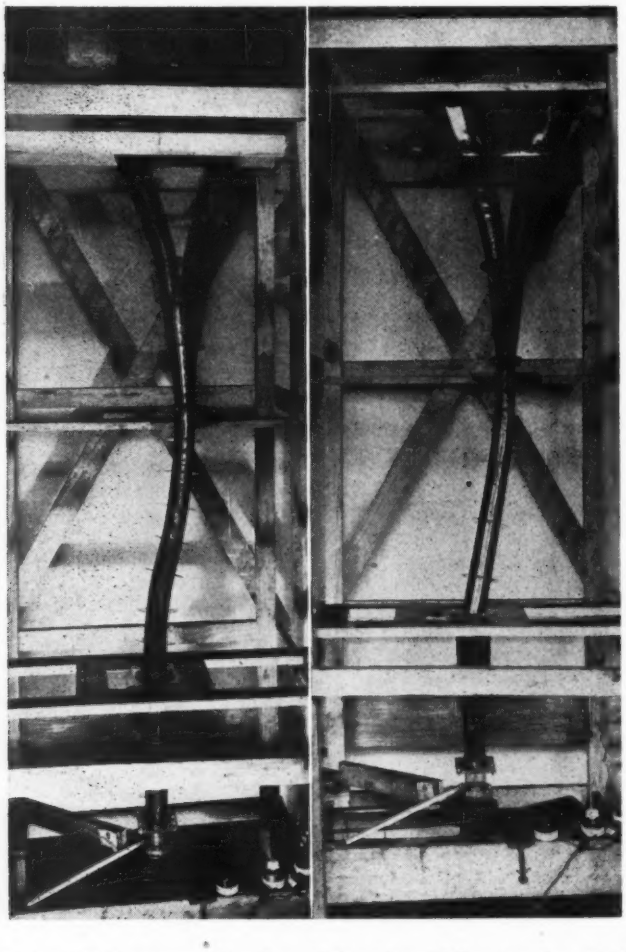

Fig. 3—Fully streamlined model and modification by single bend in flaring chute

In the range from 3.0 to 3.5 per cent moisture, stoppages occurred in the latter locations and voids began to form in the rectangular tapering chute above the operating floor. With further increase in moisture, flow of coal could be maintained through the lower hopper by means of scale-sized pokers and air lances, but arching and rat-holing then took place at the upper hopper, as shown in the several views of Fig. 2.

In this chute system, there is a reduction in cross-section from a rectangular shape at the top of 41.7 sq ft to a circular shape at the bottom of 1.7 sq ft. This large transition causes the coal to compact, producing the observed stoppages at the bottoms of the hoppers, in corners and at points of change in direction of flow.

Static Angle of Repose

One of the properties which governs the gravity flow of coal is the static angle of repose which is influenced by both moisture content and degree of compacting. With fully compacted coal, the angle of repose increases rapidly and reaches 90 deg at 3.6 per cent moisture. Consequently, at this and higher moisture contents, rat-holing can occur in hoppers and bunkers. With an increase in moisture content above 3.6 per cent, it was possible to undercut the coal. At higher moisture ranges (above 13 per cent), the wet mass of fully compacted coal had a tendency to bulge out. It may be stated, therefore, that the angle of repose for these conditions exceeds 90 deg. It is important to use the steepest possible angles, preferably 75 deg or more, in the design of coal chutes if moisture contents higher than 3 per cent are to be encountered. All of the tests have indicated that the degree of compactness or density of the coal greatly affects the flow characteristics.

Starting from 1 per cent moisture content, the density of loose coal decreases until it reaches its lowest value at approximately 7 per cent. Above 7 per cent, it rises until at 15.75 per cent it again reaches the same density as at 1 per cent moisture and continues to rise. Some other granular materials, for instance, sand, show this same phenomenon of a point of minimum density at an intermediate moisture content.

Effect of Moisture Content on Degree of Compacting

To gain a better understanding of the interrelation of moisture content and degree of compacting, additional tests were made, and the information showed that with very low moisture contents, coal can undergo full compacting without reaching an angle of repose of 90 deg and, consequently, with such coal, rat-holing is highly improbable. At 3.6 per cent moisture content and above, there is a definite degree of compacting that can take place before an angle of repose of 90 deg is reached. With an increasing moisture content, this margin diminishes.

The suitability of various materials for coal chutes was studied. A large plate was arranged in such a fashion that it could be raised slowly from the horizontal position. Various materials were attached to this plate and equal amounts of loose coal carefully placed along the top part of each material. The variations in slide angle of the materials tested were within 3 deg with coal up to a moisture content of 8 per cent. Above this point the graph shows breaks in the curves for glass, aluminum and stainless steel. This change in characteristics is

apparently due to the formation of a film of moisture on the surface of the material which permits the entire specimen of coal to slide as one mass.

These slide tests represent unrestricted flow with one surface of contact. The influence of three contact surfaces was determined by using channel-shaped metal chutes. A series of experiments was also performed with cylindrical pyralin, glass and steel tubes to determine the variations between the foregoing conditions and one in which no free surface of coal exists.

Test points incorporated on a graph, and an average curve drawn to show the trend indicates that the angle of flow increases until it reaches a maximum at 10 per cent moisture and decreases thereafter.

At least three types of flow were observed in these experiments, which account for the non-uniform behavior in the intermediate moisture ranges; these are as follows:

Granular flow, in which there is distinct movement of one particle with respect to the others, occurs with fairly dry coal.

Plug flow, in which the whole column of coal moves as one mass with no apparent relative movement of individual particles, occurs at high moisture contents.

With moisture contents corresponding to the trough of the "density-moisture curve," there exists a transition type of flow which resembles viscous flow.

The transition from granular flow to plug flow cannot be clearly defined and is influenced by the physical composition of the coal.

Flow of Coal in Pipes With Uniform and Enlarging Diameters

The wisdom of using pipes with constant increase in cross-section in direction of flow (flaring pipes) has been long recognized, and measurements were made to establish the relative merit of a flaring pipe as compared with a pipe of uniform cross-section. A piece of smooth steel tubing 9 ft in length and of a uniform 3 in. ID was set up at an angle of 60 deg and paralleled by a pipe of the same length but gradually enlarging from 3 to 4 in. ID. These pipes were carefully filled from the top and the coal was taken away from the bottom by means of a slowly rotating disk. The stoppage occurred in the 3-in. cylindrical pipe at 7 per cent moisture, while the tapering pipe was capable of carrying coal of any moisture content up to the limits of the test (16 per cent).

Observations were made on the effect of small obstructions on the angle of slide in cylindrical steel tubes. It was noted that, above 4 per cent moisture content, a very small restriction at the end of a pipe, either in the shape of a small segment, or in the shape of a minute annular ledge, was sufficient to raise the angle of slide to 90 deg, or even to prevent flow in a vertical position.

Side-Wall Support of Column of Coal by Smooth Cylindrical Pipe

Tests were made to determine the influence of a head of coal in producing flow through a chute. For this purpose, a smooth 3-in. diameter steel cylinder, 36 in. long, was arranged vertically in such manner that the bottom of the pipe was suspended over the platform of a scale without actually bearing on it. This pipe was filled in successive steps to varying heights and tests repeated with samples of varying moisture content. Curves plotted show a fairly uniform rise up to one diameter and then flatten out considerably, indicating a very small gain in pressure on the bottom from additional height of column. With increasing moisture contents, each successive curve shows lower values and, after having reached minimum values at 8 per cent, begins to rise. With fairly dry coal, approximately 80 per cent of the weight of the 36-in. high column is carried by static side-wall friction.

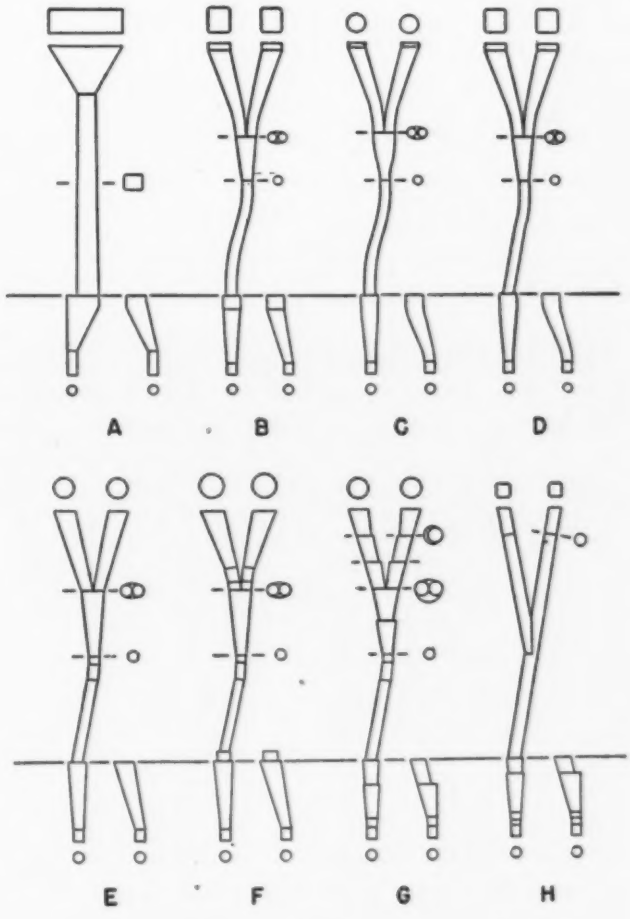

Fig. 4—Outlines of various test assemblies

Similar experiments were carried out with a flaring pipe, and it was noted that, while the bottom load was greater than for the cylinder, a large part of the load was still carried by side-wall friction and the general trend of curves remained the same. Coal which is confined in a vertical chute will exert a thrust against the side walls and, consequently, create frictional components as long as the angle of the side walls to the horizontal is greater than the static angle of repose of the coal.

In the model of the existing chute as well as in the field, it has been observed that the hoppers were focal points of trouble. For the development of a new design, it became necessary to assemble basic data on the flow of coal through hoppers with various degrees of constriction, shape and size.

The curve representing the moisture content at stoppage in cones of varying tapers increases rapidly with the increase in steepness of cones. With the sharp-angle cones it was possible to re-establish flow by further increase in moisture content. The pronounced effect of

compacting on the stoppage of coal in the hoppers was observed by a comparison of the two curves.

The use of admixtures to lubricate the sides of a chute was considered and various experiments were made to establish the effect of oils and wetting agents. No appreciable improvement of practical value was obtained with these admixtures.

Revised Model Design

Successive steps of new design incorporating certain features, to be mentioned, were tried in model form. Essentially these features are intended to approach streamlined flow of the coal similar to the flow of fluids in an efficiently designed system and are:

1. Avoidance of sudden constrictions and sharp changes in direction.
2. Minimum angles of convergence of lines of flow, preferably approaching zero.
3. Minimum practical taper in hoppers.

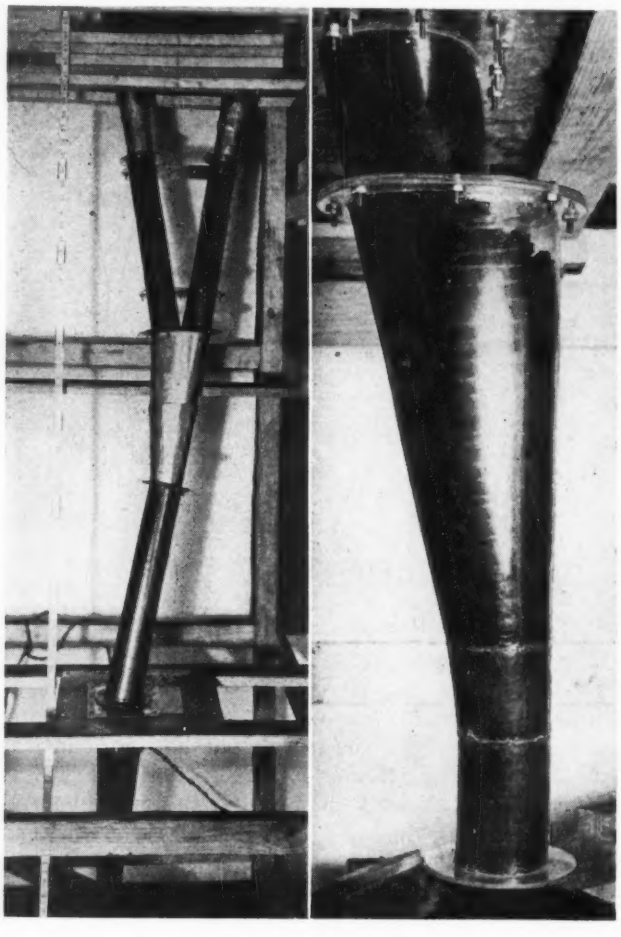

Fig. 5—Model of final design, showing upper converging section at left and that below operating level at right

4. Maximum possible angle of inclination with horizontal throughout the system.
5. Use of round shapes in preference to square or rectangular shapes.

Since existing space limitations in the plant had to be taken into consideration and the design modified to suit these conditions, it was not possible to apply fully the ideals outlined.

The first problem encountered was the hopper below the operating floor. In the present chute system, this hopper forces the coal into a two-directional lateral transition (see Fig. 1). This double transition causes

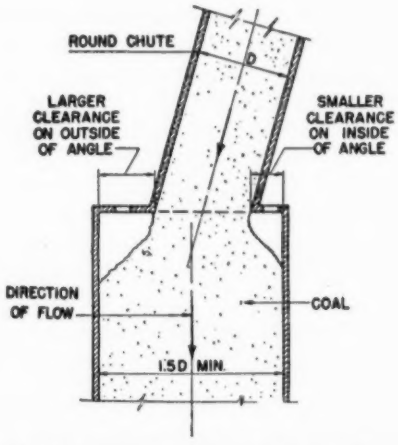

Fig. 6—Schematic section of "breakaway"

the greater part of the hopper space to be inactive. The first changes that were tried were the elimination of one transition in the hopper by shifting it to the chutes above, and the use of a conical hopper of small taper. Further alterations led to a fully streamlined hopper with a lateral transition in one plane only.

From the underside of the coal bunker to the operating level, the design possibilities were limited by the following facts: The existing coal gates for this system of chutes are spaced 8 ft apart and cannot be changed. The location of the top of the hopper below the operating floor has already been set by virtue of existing structural members and various piping below this floor. In addition to this, there are some main structural members approximately halfway between the operating floor and the bunker.

To accomplish the necessary lateral transition, a number of flared circular sections were tried, first with a reverse bend and then with a single bend and straight section.

Above this section of pipe, the problem still existed of bringing two streams of coal together, and a series of successive shapes led to the development of the completely streamlined model shown in Fig. 3.

Altogether 40 set-ups were tested covering the full range from a large, long hopper section spanning over both bunker gates at the top, to the extreme of two pipes leading from the coal gates in the most direct manner possible down to the hopper at the operating floor. Some of these various set-ups are depicted in Fig. 4.

The fully streamlined model which had been assembled and tested to explore the theoretical solution to the problem was not regarded as practical from an engineering standpoint. Since nearly every component part consists of double-curvature shapes, the difficulties encountered in building the model might easily be multiplied in the actual fabrication of a prototype. The model shapes became so sensitive that the slight distortion which the plastic pyralin model underwent during hot humid weather immediately reacted on the ability of the system to carry wet coal. Considerable effort was

devoted to the problem of simplifying these shapes to a point where manufacture would be feasible and operating effectiveness would be maintained. The final results of these tests are shown in the views of Fig. 5, which represent essentially the chute that has been ordered for a full-scale test in the plant at Riverside.

Several individual problems of interest to the designer were encountered in these tests. In the model of the existing chute, the coal had a tendency to hang up at the transition from the rectangular chute to the hopper below the operating level. This difficulty was especially noticeable where the flow from the rectangular chute was directed against a slanting side of the hopper below.

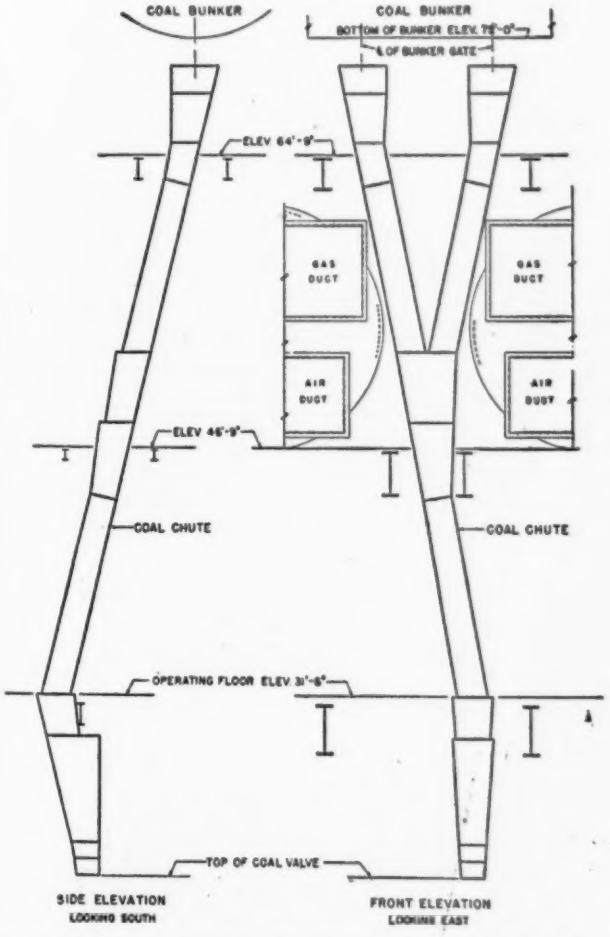

Fig. 7—General assembly of new coal chute, constructed of round or oval sections

Where this hopper stepped back, permitting the coal to fall away from the end of the chute, less trouble was encountered. This observation led to the development of the "breakaway," which consists of a free space surrounding the lower end of a chute or hopper, thereby permitting the coal flowing from the chute or hopper to break away freely in all directions, Fig. 6. This feature permits a sudden change in direction and has the added advantage of tending to counteract compacting. This device has been employed either wholly or partially in three locations in the new chute system.

Conclusions

The tests have demonstrated that phenomena occurring in a chute system can be reproduced in a scale model.

Compaction of coal is one of the most important factors influencing the operation of a solidly filled chute system. An angle of repose of 90 deg may be reached at relatively low moisture contents if the density of coal is increased through impact or wedge action. Since coal must undergo a certain amount of compacting in any composite system, there exists a limit in moisture content at which the chutes can be depended upon to operate without stoppage. The possibility of coal stoppage must be recognized and, therefore, the ease of re-establishing flow should be considered in developing a design.

It was concluded that the following points should be incorporated in the chute design. The shortest possible path from the coal bunker to the mills should be maintained. Tapered (or uniformly enlarging) round chutes should be used wherever possible. Where two streams of coal must be brought together, this should be accomplished with a minimum angle of convergence. If a sudden change in direction cannot be avoided, the introduction of a "breakaway" to help the coal to realign itself should be utilized. All angles of chutes should be made as steep as possible and reductions in cross-section kept to a minimum.

The application of all points mentioned in the foregoing has resulted in a model design which showed sufficient improvement over the model of the existing chute to justify the construction of a full-sized chute for development of actual field experience, Fig. 7.

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More About the British Grid in War

The April issue contained a brief digest of the 1940–43 reports of the Central Electricity Board concerning operation of the British Grid under wartime conditions, with particular reference to steps taken to meet rapidly growing loads. Security reasons then prevented inclusion of information concerning enemy action. The report for 1944, however, which has now been released, contains such information and shows that interruptions to service, due to escaped barrage balloons, were more than three times the number due to enemy bombs. Only one large generating station was put out of service by a direct hit. The report also deals with the present difficult fuel problem.

AN INDICATION of difficulties likely to be encountered in maintaining adequate supplies of electricity during the winter peak periods of the next few years is given in the Annual Report of the Central Electricity Board for 1944, which also amplifies the information about the operation of the Grid under war conditions as given in the four wartime reports issued earlier in the year following censorship relaxations. Those reports were restricted in their scope in order to avoid the possibility of disclosing information which might have been of value to the enemy, and the veil is now lifted from the fuller account of the Board's activities and the contribution of the Grid to the war effort to which the security black-out has hitherto applied.

During 1944, electricity generated at public supply stations in Great Britain was 38,354 million kwhr, which was 1403 million kwhr, or 3.8 per cent, more than in 1943, and 45.2 per cent more than in 1939. Of the electricity supplied by the Authorized Undertakers in the country (excluding North Scotland) during the year, 99.03 per cent was produced at stations which were generating for the Board. At the end of the year, there were 141 selected stations associated with the Grid, while 48 others were operating under temporary arrangements. The selected stations had an aggregate installed capacity of 11,254,081 kw. The Grid itself comprised 5142 miles of transmission lines, 3614 operating at 132,000 volts and 1528 at 66,000 or lower voltages, and 348 switching and transforming stations with an aggregate transformer capacity of 13,422,750 kva.

High Outage Reported

The maximum simultaneous demand on the Grid System, which occurred on December 29, 1944, was 8,351,000 kw, as compared with a maximum demand of 7,867,000 kw in the previous year. The amount of plant out of service on that day exceeded 18 per cent of the aggregate output capacity of all the generating stations operating under the directions of the Board as compared with the pre-war percentage of approximately 6 per cent. On two occasions during last November, when, owing to the demands for electricity consequent upon a spell of exceptionally cold weather, it had been necessary for short periods to shed load in the southern part of the country. On each occasion this amounted to some 200,000 kw, which represented about $2^1/_2$ per cent of the load on the system. Plant capacity out of service from all causes amounted to 2,657,000 kw and 2,368,000 kw, representing 26 per cent and 23 per cent, respectively, of the aggregate output capacity. Indicating the reasons for this large increase in the amount of plant out of service, the Board again stresses the difficulties of carrying out maintenance and overhaul work, and stated that, despite endeavors to obtain an increase in the labor required, the number of men actually obtained, averaged over the year only 44 per cent of those required. The load factor on the Grid System, namely 47.6 per cent, was about the same as in 1943.

Dealing with the coal situation the report shows that, although the increase in the consumption of electricity involved an increase in the amount of coal required, coal stocks were built up to a maximum of only 3,550,000 tons as compared with 3,860,000 tons in the previous year. The replenishment of stocks during the summer of 1945 to the extent necessary for safety will present grave difficulties. In addition to the difficulty of obtaining the necessary quantities of coal, there was continued difficulty in obtaining supplies of suitable qualities, and it is stated that the total reduction in generating capacity due to this cause has on occasions been as high as 300,000 kw.

Coal Prices Advance 85 Per Cent

Reference is made to the adverse effect of the rapid increase in the price of coal upon the cost of production at the generating stations. These had, in general, been designed to burn low grades of coal at prices which had hitherto been substantially below the average. During the war period, the national average price of coal at the pithead has been raised by some 85 per cent over the 1938 figure. As this has been brought about by flat rate increases, the rise in the price of coal delivered to generating stations has been relatively greater than the rise in the average price in the home market as a whole, to the consequent prejudice of the electric supply industry. The average price of coal at all the steam stations operating under the directions of the Board in 1944 was approximately 39/- (approximately $8.00), the corresponding figures in 1935 and 1938 being 14/9d and 20/3d, respectively. The average cost of coal per kilowatt-hour sent out in 1944 had risen by some 99 per cent over the 1938 level.

Extent of War Damage

The first, and for some time the only, war damage to the Grid lines was occasioned by the lines being fouled by the anchor cables of escaped barrage balloons. From the outbreak of the war to the end of 1943, there were no fewer than 1979 faults attributable to war causes, of which nearly 73 per cent were due to barrage balloons, about 13 per cent to low flying aircraft and shrapnel from anti-aircraft guns, while only some 14 per cent were directly attributable to enemy action. More than two-thirds of the faults were cleared without interruption to service. During four months of the Battle of Britain, August to November 1940, there were no fewer than 456 faults due to escaped barrage balloons and 126 caused by bombs. In the month of September 1940, the faults from these two causes in Southeast England exceeded the total number of faults in that area from all causes throughout the whole of 1938. There were short interruptions, but despite all difficulties the Grid continued to function successfully and, in general, service was maintained. The first occasion on which one of the steel latticework transmission towers was totally destroyed by bombs was not until February 1944.

An emergency control room which had been built in London for the southeast and eastern areas was rendered uninhabitable and the staff and equipment of the main control room were transferred early in 1941 to safer accommodations in two discontinued elevator shafts leased from the London Passenger Transport Board. Additional facilities were incorporated in the new premises to provide for a national control center. The emergency control room in Birmingham for Central England was twice destroyed. Owing to the precautionary measures taken, communication for control was always available in each district. The nearest approach to a complete dislocation of the communicating system in any district occurred in Southeast England following the raid on the night of May 10, 1941, when thirty-four, out of a total of sixty-three, private lines were put out of action.

Damage to the Board's substations was less than had been anticipated and in only a few cases involved any prolonged interruption of service. Frequently, when bombs fell in the vicinity, their effect was neutralized by the blast walls which proved very effective. Where serious damage did occur, it was possible, by means of temporary arrangements, to maintain or restore temporary service, pending completion of permanent repairs, although such arrangements involved some added difficulties of operation.

Generally speaking, the loss of generating plant capacity caused by air raids was less than had been feared. The most serious incident was the damage to the Fulham generating station on September 9, 1940, when bombs fell on the turbine room and put 190,000-kw capacity out of service. Fortunately the Board's substation and the interconnecting transformers and cables were undamaged and it was therefore possible to resume within a few hours and thereafter to maintain local service from the Grid system. The loss of capacity due to enemy action has varied, but never exceeded 400,000 kw at any one time.

The problem of meeting the changed distribution of load following the establishment of munition works in the West could not be met by the erection of new generating stations in time and the rapid increase of demand was met by the construction, during 1941 and 1942, of 363 miles of additional 132,000-volt transmission lines (known as War Grid Reinforcements), designed to transfer energy into the areas in which the new factories had been built from the areas which had experienced a reduction of load. At the time this was done, the manufacturing resources of the country were already fully employed on the production of munitions and, in consequence, contracts for the towers and the cadmium copper required for the conductors were placed in the United States. Only two of the 52 shipments were lost owing to U-boats, involving the loss of 346 tons of steel towers and 104 tons of cadmium copper. A further 30 tons of steel towers and 100 tons of cadmium copper conductor were destroyed by air raids after they had been landed. During the same period, 71 miles of 132,000-volt lines and 58 miles of lower voltage lines were built for the sole purpose of providing supplies to large new war factories.

The change in the distribution of load resulted in heavy transfers of energy between areas. Before the war, Southwest England and South Wales were exporting areas for electricity, while the Southeast England area was an importing center. Upon the outbreak of war, however, the position was reversed. The load in Southeast England fell off to a greater extent than in any other area and so released plant capacity for exports, particularly to South Wales, where a considerable concentration of war factories was rapidly being established.

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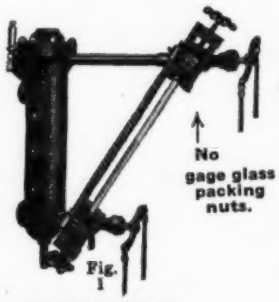

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Fig. 1 with Split-Gland Gages Inclined

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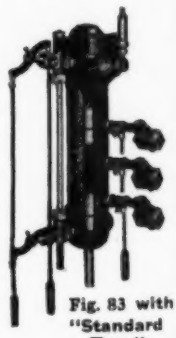

Fig. 83 with "Standard Type" Vertical Gages

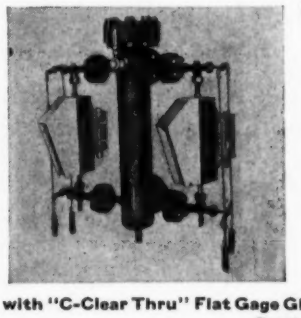

Fig. 85

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Coal Outlook Not Optimistic

Bituminous coal output for the first four months of this year was nearly 18 million tons under that of the corresponding period last year. Although unusually warm weather in March cut consumption considerably and withdrawals from stockpiles were not as great as they otherwise might have been, the drop in production leaves no room for optimism as to the fuel situation.

Moreover, on May 5 the Government found it necessary to take possession of 33 bituminous coal mines which had remained idle since approval of the new contract between the United Mine Workers and the operators on April 30. Over 10,000 workers were involved. This increased to 272 the number of soft coal mines in possession of the Government because of strikes following the expiration of the old mine wage agreement on March 31. Some of these stoppages cut deeply into the output of the important Alabama-Southeastern Tennessee district. The total deficit to date has been estimated by the Solid Fuels Administration as 25 million tons, or more.

In the anthracite field, 1945 production had been running consistently below that of 1944, even prior to the complete shutdown since the expiration of the wage contract on April 30, despite Government control. After more than a week of idleness there was no immediate prospect of resumption and the loss in production will be irretrievable.

Patent System Revisions Will Be Urged

It is reported that Secretary of Commerce Wallace, within whose jurisdiction falls the Patent Office, is preparing to urge upon the President and Congress a revision of the patent laws. Among the proposals which are understood to be under consideration are: (1) outlawing of patent suppression which would compel the holder to use or forfeit a patent; (2) compulsory licensing, by which the owner of a patent would be required to let others use it upon payment of royalty; (3) the public registration of all patent licensing agreements; and (4) the forfeit of any patents that may be employed in violation of anti-trust laws or which may be concerned with any international cartel. It is also contemplated to exercise stricter control over the issuance of patents to the end that fewer suits for infringement may result.

These proposals are not new. Several of them are covered in bills that have been introduced in Congress during the last three or four years. The underlying purpose has been to restrain monopoly and encourage independent invention, but many qualified individuals have expressed the opinion that industrial research would be stifled by some of these proposals. In this respect, compulsory licensing comes in for the greatest criticism. Mr. Wallace is said to feel that a revision of the patent system along the lines suggested would result in stimulating new industries and thereby provide more employment.

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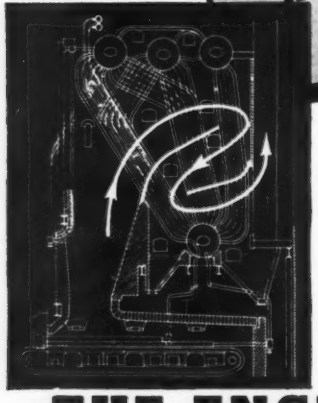

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Energy Production

The Federal Power Commission states that reports received during April indicate that the capacity of electric generating plants in utility service totaled 49,392,629 kw as of March 31, 1945. Scheduled net additions during the current year are estimated at 820,640 kw. The combined utility and industrial generating capacity is given as 62,197,091 kw. Figures on industrial production of electricity are based on reports from 800 plants, representing an estimated 85 per cent of the total, and extended to cover 100 per cent. The curve for total production which fell off sharply early in the year is again showing an upward trend.

Total production of electricity for public use for the twelve months ending March 31, 1945, exceeded 228 billion kilowatt-hours which represented an increase of 1.5 per cent over the preceding twelve months. Peak utility demands during March aggregated 37,151,429 kw, and water power accounted for 38.3 per cent of the total generated for public use.

Coal consumption by the electric utility power plants was 6,463,422 tons in March; oil consumption was 1,575,561 bbl; and gas consumption amounted to 25,312,845 mfc. Stocks of coal on hand as of April 1 showed a decrease of 2.8 per cent during the previous month and represented an average of 63 days' supply for bituminous coal.

Obituaries

Hans Nielsen Boetcher, Assistant to the Superintendent of Power Production Stations Department, Consolidated Gas Electric Light and Power Company of Baltimore, died in that city on April 19, 1945, after a short illness. He was 47 years of age.

A native of Hamburg, Germany, Mr. Boetcher received his formal education at the Technical University in Hanover. Prior to his coming to this country in 1924, he was with the Siemans Electric Works, Hamburg. Continuing in the field of engineering associated with the generation of electric power, he entered the employ of the Consolidated Gas Electric Light and Power Company in 1925. Engaged primarily with the design, construction and operation of steam electric generating plants, Mr. Boetcher was prominent in recent years in metallurgy as applied to the power industry.

He was a member of the American Society of Mechanical Engineers and of the Prime Movers Committee of the Edison Electric Institute. He was also a committee member of the American Society for Testing Materials, being chairman of the subgroup on "Graphitization of High Temperature Pipe," and was an associate member of the American Welding Society.

F. B. Allen, president of the Allen-Sherman-Hoff Company, of Philadelphia, died suddenly from a heart attack on April 8 at the age of 58. A graduate of Case School of Applied Science, Mr. Allen was widely known among power engineers for his work on ash disposal.

Ferrules Overcome Leaky Joints

A recent paper by Messrs. Shannon, Pratt, Webb and Carlson, before a joint meeting of The Institution of Mechanical Engineers and The Institution of Electrical Engineers (England), describes in detail the experience with expanded tube joints in the drums of the two latest high-pressure boilers at Battersea Power Station of the London Power Company.

The boilers concerned are each of 550,000 lb per hr maximum continuous capacity at 1420 psi, 965 F at the superheater outlet, the drum working pressure being 1550 psi (1660 psi design). They are of the three-drum type plus a dry drum. In order to reduce weight and keep the plate thickness down to $3\,^{7}/_{8}$ in. and under, a nickel-chromium-molybdenum steel of 42 tons per square inch ultimate tensile strength at 660 F was selected for the drum, together with mild steel tubes. The factor of safety was 4.

The tube seats were $1\,^{1}/_{4}$ in. long with one semi-circular groove $^{1}/_{8}$ in. wide and $^{1}/_{16}$ in. deep in the center. However, due to the high design stress of the drums, in conjunction with the mild steel tubes, it was practically impossible to maintain tight joints, even after re-rolling. Therefore, the first unit was operated for several months at a reduced pressure of 800 psi while investigations were being carried on with the second unit.

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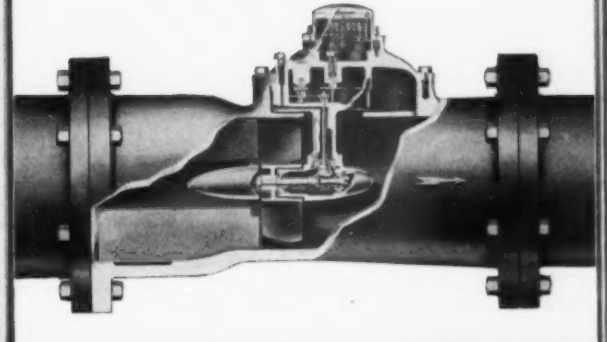

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High Lift Pop Valve

Farris Engineering Company has developed a pop relief valve reported as having an exceptionally high coefficient of lift for the disk. This high lift is secured through the unique design of the valve disk, by which the velocity of the fluid is entrapped and its kinetic force converted into additional lift for higher relief discharge. The new Farris pop valves (Type No. 1800) designed for pressures up to 300 lb are made in sizes $^1/_2$ in. to $2^1/_2$ in. and meet full A.S.M.E. specifications. The valve is built with an adjustable single blow-down ring which permits regulation of the amount of pressure to be relieved on individual operations.

Another new Farris pop valve (Utility Type No. 1840) is built without an adjustable blow-down ring, which is replaced by a predetermined orifice. This valve is made in sizes $^3/_8$-in to 1 in.

Lens for Cat's-Eyes

The Ess Instrument Company announces the development of a new lens, for its Cat's-Eyes, to permit visual inspection of boiler and furnace interiors and their contents, while in operation. This new lens "Type O" provides a wider field of vision with less reduction than is available through a standard type "G" lens. Both are interchangeable. It is claimed that

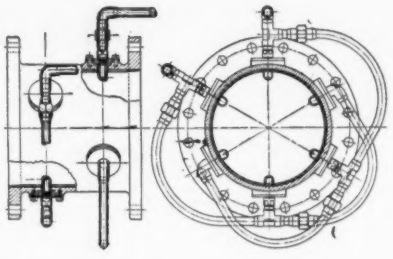
Cat's-Eyes equipped with Type "O" lenses will show, at a glance from distant points, the flame with its characteristics of color, turbulence and haze, and objects inside a boiler or furnace such as tubes and articles being heat treated, etc.

Water-Service Packing

To meet the need for a general utility lubricated centrifugal pump packing Greene, Tweed & Co. has developed Palmetto Plated Packing. In this new packing, long-fiber asbestos yarn is used instead of cotton, with the advantage that the packing can be used for hot water as well as cold water. The lubricant is Palmetto Graphite grease, an exclusive Greene Tweed compound which thoroughly impregnates every individual fiber of the packing. The packing is plaited in square form, and is made in a wide range of sizes. Equipment for which this packing is recommended includes centrifugal pump shafts, reciprocating pump rods and plungers, valves, fire hydrants and other apparatus handling hot or cold water.

Flow Tube

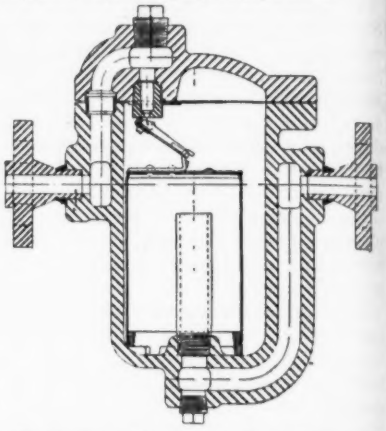
The Coldwell-Wilcox Division, Krajewski-Pesant Manufacturing Corp., announces a new primary element known as the Gentile Flow Tube for metering fluids and which uses the average velocity immediately adjacent to the wall of a pipe or conduit as a criterion of flow. It consists



simply of a short length of pipe, on the inner periphery of which are mounted two groups of pressure nozzles, one group pointing upstream and the other downstream. The nozzle groups are interconnected by common pressure rings from which connections are made to the high and low pressure sides, respectively, of a recording and integrating meter.

Cast Steel Steam Trap

Designed for pressures up to 600 lb, or where all steel fittings are desired, a new cast steel inverted bucket steam trap with side inlet, side outlet pipe connections, has been announced by the Armstrong Machine Works. It is available with $^1/_2$-in., $^3/_4$-in. or 1-in. screwed or flanged connections. Flanges are welded into the trap body. Height is $11^1/_4$ in.; dimensions between flanges range from $11^3/_8$ in. to $12^1/_8$ in., depending upon pipe sizes.



The inverted bucket and valve lever are made of 18–8 stainless steel; the valve and seat are chrome-steel hardened, ground and lapped. One of the features of the trap is that the cap and interior mechanism can be removed for inspection or repair without breaking either the outlet or inlet connections. The cap and working parts are removed as a unit by unbolting the cap.

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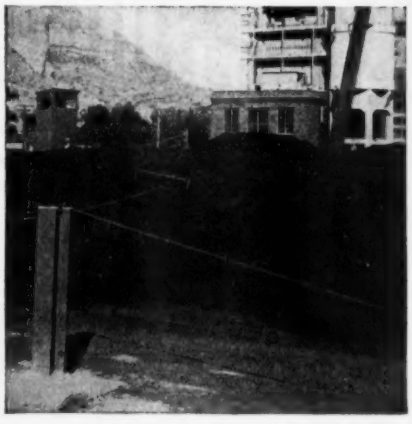

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